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A SKULL BREAKER IN A LIMESTONE QUARRY

BY

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

A SKULL BREAKER IN A LIMESTONE QUARRY[1]

By McHenry Mosier[2]

SUMMARY

A skull breaker has demonstrated its advantages for secondary breaking in a limestone quarry by entirely displacing secondary blasting. It has reduced safety hazards to workmen, increased the number of quarry operating days, and has lowered mining costs by 2.7 cents a ton. It is believed that the application of the skull breaker can be made economically advantageous in the surface mining of other commodities.

INTRODUCTION AND ACKNOWLEDGMENTS

A skull breaker is used in one of the quarries of the White Rock Quarries, Inc., at Pleasant Gap, Centre County, Pa., for secondary breaking in lieu of blockholing and blasting. Ray C. Noll, who is president and general manager of this company, furnished the operating data for this paper in December 1947. The quarry operates one shift a day, 5 days a week, and produces 1500 tons of crude limestone a shift.

GEOLOGY AND MINERAL DRESSING

Beds of high-grade Ordovician limestone about 70 feet thick dip about 20 degrees through a strike length of several miles. This stone averages 98 percent $CaCO_3$ at Pleasant Gap. Contiguous beds of lower-grade limestone are many hundreds of feet thick.

The limestone is crushed, screened, ground, and loaded on railroad cars at a plant about 1 mile from the quarry. No calcining or "burning" is done at Pleasant Gap.

The limestone weighs 160 pounds a cubic foot, which corresponds to a weight factor of 12.5 cubic feet a ton.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7472."

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QUARRYING

The principal quarry at Pleasant Gap is 1,600 feet long and 600 feet wide, and the maximum height of the quarry wall is 130 feet. The floor is kept clear of rocks from blasting and spillage from truck haulage, so that it is perfectly smooth and clean.

A blast-hole rig powered with a gasoline engine drills 7-inch holes with a 6-3/4-inch bit at an average rate of 40 feet a shift, including moving. The tools, which weigh 2,737 pounds, drop 54 times a minute through a vertical fall of 4 feet and 8 inches. The maximum depth of holes is 75 feet. The total cost of drilling if $0.75 a foot.

Blasting is accomplished by black powder and detonating fuse in a single row of holes which are drilled 3 feet below grade, to insure that no high bottom develops.

Six men work at the quarry, exclusive of transportation, as below:

2 Blast-hole drillers
2 Shovel operators
1 Skull-breaker operator
1 Foreman

Two Diesel-powered shovels with 1-yard dippers are mounted on crawlers. At 1,200 r.p.m. their engines develop 100 horsepower each. One shovel easily loads 750 tons per shift. In addition to his duties as supervisor, the foreman also finds time to sweep the quarry floor with a gravity blade mounted on a rubber-tired tractor.

Six 8-ton dump trucks deliver the limestone from the shovels to an industrial railroad, which runs from a loading station at the entrance of the quarry to the crushing plant.

SKULL-BREAKER DESIGN

The skull breaker is a machine comprised of a 2-ton manganese-steel ball suspended from a crane that weighs 30 tons. The crane was a converted 1-yard shovel powered by a 125 H.P. gasoline engine. Its 40-foot box boom has a lifting capacity of 12 tons. The machine is mounted on crawlers. The breaking head from a gyratory crusher was tried in lieu of a ball, but the shape did not prove entirely satisfactory in realizing the maximum effect from each blow. The steel ball is roughly spherical and has a maximum horizontal diameter of 30 inches and a vertical height of 26 inches. As eye bolts proved unsatisfactory, the hitch for its suspension was made by boring a hole through the ball and driving in it a 3-inch diameter, cold-rolled steel shaft. A manganese-steel anchor chain was attached to the ball as illustrated in figure 1. A standard clevice with swivel connected the other end of the chain to the steel rope, which was operated by the winch in the crane. The life of a chain is 10 days.

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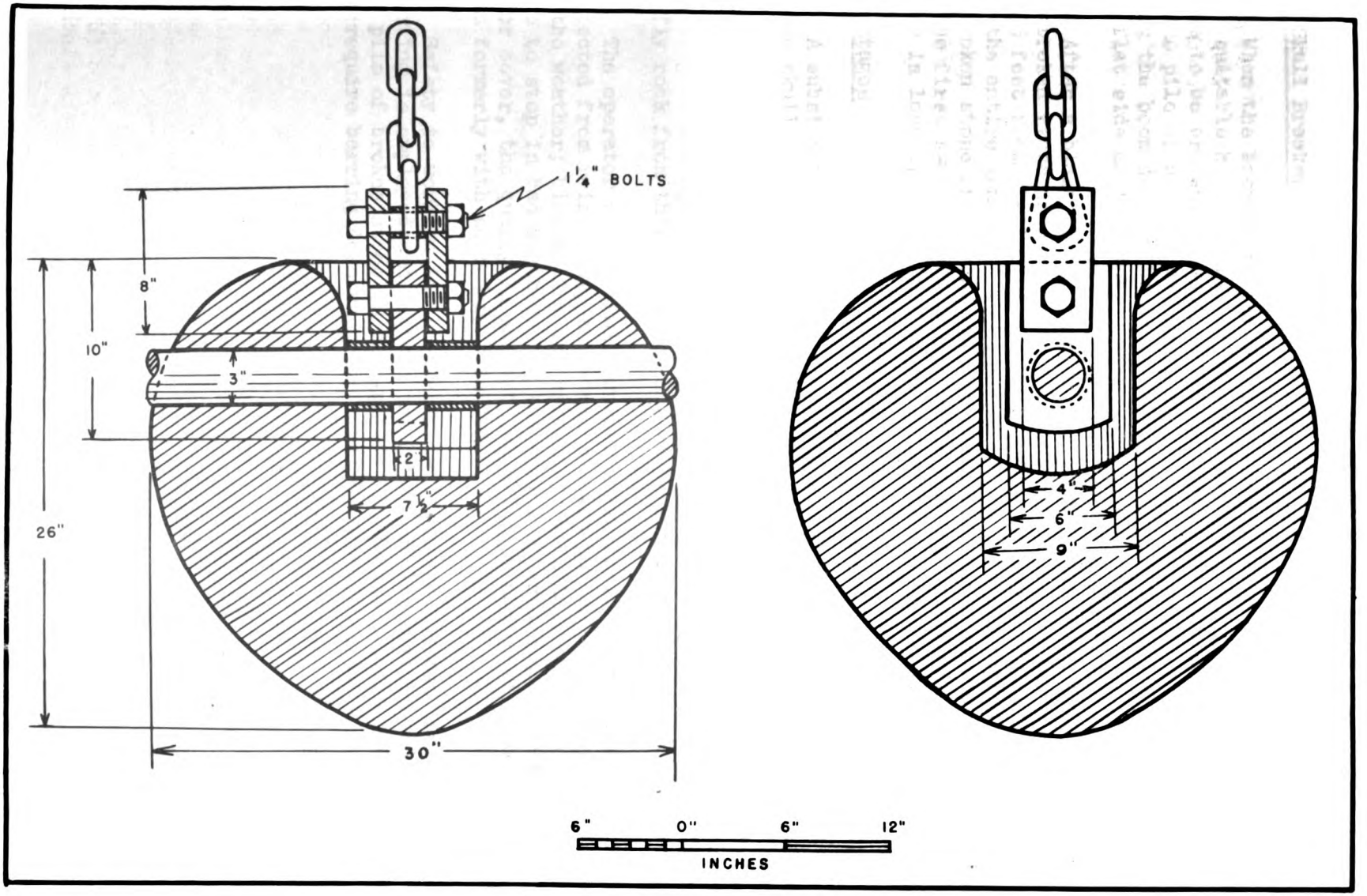

Figure 1. - Hitch for suspension of ball.

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The Skull Breaker

When the boom of the crane is in the proper position, the ball is lifted to a suitable height, usually 25 or 30 feet, and dropped upon the slab of stone to be broken. Sometimes two or three blows are required. When a slab in the pile of broken rock rests in an inclined position, the operator may swing the boom just as he drops the ball, so as to direct a blow normal to the flat side of the slab.

After a blast at the face of the quarry, the skull breaker works over the broken stone in advance of the power shovels. It has a horizontal reach of 35 feet from the toe of the pile. When it has finished the first swath for the entire length of the quarry, it moves to the opposite end of the pile of broken stone and begins another swath behind the shovels, which are working on the first swath. Subsequent swaths continue until the entire pile of stone is loaded. When another blast is fired, the sequence is repeated.

Advantages

A substantial reduction in operating costs has resulted through the use of the skull breaker. It has replaced secondary blasting, which required two drillers with plugger drills and one shot-firer. It has eliminated the operation of a compressor, the laying of compressed-air lines, and the use of explosives within the quarry. Thus, the shovels do not have to stop for blasting boulders, and the crew loses no time waiting for secondary blasting. No fly rock from this operation has to be removed from the quarry floor.

The operator of the skull breaker works inside a cab on the crane, protected from rain, snow, and wind, so that he can work every day regardless of the weather; blockholing and secondary blasting, on the contrary, would have to stop in bad weather. As the shovel operators and truck drivers work under cover, the quarry is maintaining a larger number of operating days than formerly with secondary blasting.

Safety to workmen in the quarry is increased, because no secondary blasting is employed and because the hazard of large rocks rolling down the pile of broken stone is eliminated. Incidentally, the rock pile does not require barring down when the skull breaker is used.

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Cost Comparisons

On a 40-hour week basis, the estimated daily savings through the operation of the skull breaker are indicated below on an output of 1,500 tons:

Secondary blasting	Saving	Skull breaker	Saving
Labor:			
2 drillers @ $8	$16	1 Craneman	$10.00
1 Shot Firer @ $10	10		
Supplies: Explosives	20	Gasoline: 25 gal. @ $0.20	5.00
		Oil: 2 qt. @ 0.25	0.50
Compressed air:			
Compressor upkeep, repairs, and obsolescence	20	Crane maintenance	10.00
Total	66		25.50
Savings			40.50

The corresponding savings per ton of quarry output is 2.7 cents.

CONCLUSIONS

Experience with the skull breaker in this quarry indicates the need for heavier equipment. The management plans to procure a 3-ton ball and a correspondingly heavier crane, which should improve the speed and efficiency of the secondary breaking.

Although skull breakers have been used for years in smelters, junk yards, and industrial plants, they are novel in limestone quarries. It is believed that application of the skull breaker can be made economically advantageous in the surface-mining of other commodities.

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